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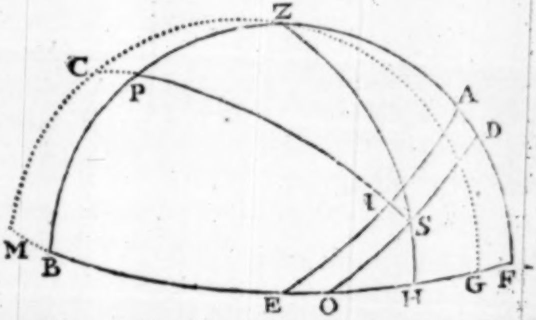
A DISCOVRSE MATHEMATICAL ON THE VARIATION OF THE MAGNETICALL *Needle.*

Together with Its admirable Diminution lately diſcovered.

By *Henry Gellibrand* Profeſſor of Aſtronomie *in Greſham College.*



Veniet tempus, quo iſta quæ nunc latent, in lucem dies extrahat, et longioris ævi diligentia. Sen. Nat: Quæſt. lib. 7. cap. 25.

LONDON,
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BIBLIO [illegible]

A DISCOVRSE MATHEMATICALL on the variation of the *Magneticall Needle.*

TO write an *Encomiaſtique* of the *Magnet* is not my intention; the bold & confident attempts of Seamen, thorough thoſe hidden paths of the vaſt Ocean, to all navigable parts of the earth, will ſpare me the labour; neither will theſe few lines permit me to ſpeake of all Magneticall qualities, they that liſt may have recourſe for their ſatisfaction herein, to that moſt learned worke (admired by all Foreiners) long agoe penned by *Mr. Dr. Gilbert* our countryman, ſometimes Phyſitian to that Renowned *Lady* our late *Queene*. That which I here principally ayme at, is the deflection of the *Needle* from the Terreſtriall *Meridian*, together with that abſtruſe and admirable variation of the Variation, lately diſcovered to the world.

The Variation then is the deflection of the *Magneticall Meridian* from the *Terreſtriall*, the *Horizon* determining its Quantitie and Qualitie. Theſe *Meridians* ſometimes are coincident, and in ſuch places there can be no Variation: Sometimes againe they are different, and then that *Hemiſphere* wherein either extremity of the Needle lyes, denominates its Quality, for if it be the Eaſterne *Hemiſphere*, it is called Eaſterly variation, if the weſterne, weſterly. And the Horizon ſuppoſed (as all great Circles are) to be divided into 360 parts, & each part ſubdivided into *Centeſmes* or *Milleſmes*, defines the Quantity as 10, 20, 30, &c. parts of variation.

For our more diſtinct proceeding (and to give ſome ſatisfaction to thoſe that are not altogether *Mathematicall*) it will not be impertinent to our preſent purpoſe to give ſome probable Reaſon for this variation or ſwarving of the *Needle* from the meridians of moſt places.

Take a vigorous *Magnet*, convert it into a *Sphericall* Body, and having found its *Poles*, delineat the ſame with *Meridians*, the *Aequinoctiall*, and *Parallells*. Then take a fine ſowing *Needle*, and applying it to the interſection of a *Meridian* and the *Aequinoctiall*, it will be found preciſely to point out the *Poles* of the ſtone; and if the *Needle* be moved towards either Pole, according to its owne direction, it will trace out a Circle over the ſaid *Magnetique Pole*. But if this *Spharicall Magnet* ſhall have a part of it excavated, as admitt about the forty fift *Paralell*, and forty fift *Meridian* or degree of longitude, the *Needle* moued forwards from the foreſaid interſection, aſſoone as it ſhall draw neere to the limb of this excavation, will forthwith leave its former poſition, as lying in the plane of the prime meridian, and incline to the other ſolide ſide, not reſpecting at all the aforeſaid Poles: and this deflection we call the variation of the *Needle*: And the greater will this variation be, the neerer it approacheth to the *Poles*. For

whereas

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whereas before the excavation each ſide being a like potent, the *Needle* like an upright and indifferent Arbiter inclined to neither part; after the excavation it will convert it ſelfe to the more ſolide ſide, rejecting the imperfect and defective, and ſo much the more powerfully, by how much the other ſide ſhall be found to have loſt more of its *Magnetique* vigorous ſubſtance.

Which may be ſome cauſe of thoſe ſuddaine and exorbitant variations in the Nortweſt and other Northerne & Southerne parts of the Earth.

The like will fall out if the *Needle* be ſo placed, as that it ſhall biſect the excavated part, for then will it acurately point out the true Poles of the ſtone formerly found, but ſuddainely ſwarue from them after any little diſlocation, ſtrongly applying it ſelfe to the more ſolide ſide.

As it is with this little, ſo likewiſe with the greater *Magnet* the Earth, whoſe ſolide magnetique parts are great Continents, the defective and excavated, the deepe and vaſt channell of the Sea. For if there were obſervations made in the midd way betweene the Eaſterly Coaſt of *China* and this weſterne of Europe, it is very probable there would be found no variation at all, the Terreſtriall and *Magneticall Meridians* being congruall; but if we ſhall incline to either ſide, as admit to the weſtward, the *Needle* will in like manner move it ſelfe to the Eaſterne Continent, as the more prevalent ſide, the channell of the Sea being a part deficient of the Sphericall Body of the Earth, and the *Needle* finding no incouragement to apply it ſelfe thereto.

And ſo likewiſe for the Ocean, which palliates the imperfect parts of the Earth, it is evident, that if the

Needle

Needle ſhall equally divide the Marine diſtance between two continents, there will be found no variation, as having both the Meridians united, the *Needle* equally diſpoſing itſelfe to either Continent. But if we ſhall ſwerue from this mediety, it will preponderate with the next continent.

For the evidence of the truth hereof, let a man examaine generally the variations of our moſt expert Seamen, (a Catalogue wherof we have annexed to that accurate worke of *Mr. Wright* in his detection and conection of errors in *Navigation*) (although by reaſon of the diverſities of the ſetts of their Compaſſes and oftentimes unapt handling of their inſtruments, they very ſeldome concurre) obſerued in the *Atlantique* Ocean, from the Equator unto the parts of *Norway*, all along the Eaſt Coaſt from the *Meridian* of the *Azores*, as farre North as hath beene diſcovered, and he ſhall finde the ordinary practiſe to teſtifie the truth hereof. As alſo after the ſame manner from the *Equator* ſouthward, unto the ſtreights of *Magellan*, and all along the backe parts of *America* in the South Sea, and on the Eaſt Coaſt unto the Cape of *Bona Speranza*, and he ſhall perceive the like agreement; But in ſayling from the aforeſaid Cape further Eaſtward, that ſometime they doe finde it otherwiſe, the cauſe proceedeth from the different ſituation of the South Continent hitherto undiſcovered. And whereas in the *Atlantique* Ocean about 135 leagues from the Ilands of *Corues* and *Flores* to the weſtward, there hath beene found by an able Artiſt no variation at all, it is a manifeſt argument, that the Place is equidiſtant from the *European* or *Affrican* continents and the *American*: And as we approach to either

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ther Continent, ſo ſhall we find the *Needle* præpotent in its converſion; from whence the variation ſhall receive its denomination.

Therefore its abſurd for Seamen to touch their Compaſſes with the allowance of the variation of any particular place, conſidering this variation is perpetually variable according to the ſhipps motion.

And moreover its abſolutely neceſſary for that Seaman who ſailes by his Compaſſe, continually to ſearch the variatiō, that ſo by the *Proſthaphareticall* application thereof, the true point of the compaſſe (which is his principall *Mercurialiſt*) may be rectified.

And this artifice may be performed by the aſſiſtance of the Planets or fixed *Starres*, and that either without or with their Altitudes. I ſhall not need to exemplify all varieties, as having elſwhere copiouſly and demonſtratively delivered the ſame. I thinke it only convenient to touch lightly at one or two, and ſuch as beſt conduce to our preſent purpoſe.

And firſt without an *Altitude*. Finde two fixed Starres of equall right Aſcention, and holding vp a thread and plummer, obſerve when the thread biſects them (for that is the exact *Meridian* of the place) and at that inſtant apply the Compaſſe to them; if the *Needle* preciſely reſpect them, there is no variation; if not, then is the difference, the variation inquired; and that part of the Horizon to which it inclines, (alwayes accounting from the ſame interſection of the Horizon and *Meridian*) claimes it.

It may likewiſe be performed by the Amplitude *Ortive* or *Occiduall* of the Sunne, and as well by night as by day, by the reſt of the Planets or fixed Starres, having onely their declinations and the Latitude of the places, either *Geometrically* by an *Analemme*, or *Arithmetically* by the helpe of the *Canon* of *Triangles*, for the ordinary termes of the proportion runne thus.

As the *Sine* complement of the Latitude, is to the *Radius*, So the *Sine* of the declination, to the Sine of the Amplitude. Turning therefore the Compaſſe to the Sunne or Starres, the difference of the Arcs is the variation inquired. Or by knowing the time of the Sunnes incidence into the Plane of the Prime verticall, after the like manner we may obtaine our deſires.

But in theſe and ſome other wayes, we are confined to a certaine time: If therefore to the former requiſits we ſhall add an Altitude, this Artifice may be performed at any convenient appearance of a Planet or Starre, as we ſhall by and by ſhew.

And for the more eaſie and certayne obtaining of the variation at Sea, I would adviſe the Sea-man to extend or prolong the capitall of his *Needle*, or fix ſome ſtile on it, ſo that it may cut the Flye at right *Angles*, for then the Compaſſe coverted to the Sun, this ſtile will readily ſhadow out the *Azimuth Magneticall*, and comparing it with that of the Sunne, he hath the variation neere enough without any further labour or preparation.

Thus hitherto (according to the Tenents of all our *Magneticall* Philoſophers) we have ſuppoſed the variations of all particular places to continue one and the ſame: So that when a Seaman ſhall happly returne to a place where formerly he found the ſame variation, he may hence conclude, he is in the ſame former *Longitude*

gitude. For it is the Aſſertion of *Mr. Dr. Gilberts. Variatio vnicuiuſq; Loci conſtans eſt*, that is to ſay, the ſame place doth alwayes retaine the ſame variation. Neither hath this Aſſertion (for ought I ever heard) been queſtioned by any man. But moſt diligent magneticall obſervations have plainely offred violence to the ſame, and proved the contrary, namely that the variation is accompanied with a variation. For whereas in the yeare 1580 *Mr. Burrows* (a man of unqueſtionable abilities in the *Mathematiques*) found the variation at *Limhouſe* neere *London* to be 11 gr. 15 min. or neere one point of the Compaſſe; In the yeare 1622 *Mr. Gunter* ſometimes profeſſor of *Aſtronomie* in *Greſham Colledge*, found the variation in the ſame place to be but 6 gr. 13 min. And my ſelfe this preſent yeare 1634 with ſome friends had recourſe to *Dedpford* (where Mr. *Gunter* had heretofore made the ſame obſervations with thoſe at *Limehouſe*) and found it not much to exceed 4 degrees.

For the clearer manifeſtation of this truth, (becauſe all men have not beene furniſhed with or ſeene the fore ſaid obſervations, I hold it neceſſary to transferre theirs hither, and ſubnect thoſe which were lately made by my ſelfe with the aſſiſtance of ſome friends.

Mr. *Burrowes* his obſervations made at *Limehouſe October*. 16. 1580.

Before Noone.				*After Noone.*						
Elevation of the ⊙		*variation of the ſhadow from the North of the Needle to the weſtwards.*		*Elevation of the ⊙*		*variat: of the ſhadow from the North of the Needle to the Eaſtward*		*variat. of the Needle from the Pole or Axis.*		
Gr.	*Min*	Gr.	*Min.*	Gr.	*Min*	Gr.	*Min.*	Gr,	*Min.*	*Sec.*
17:	0	52,	35	17:	0	30:	0	11:	17,	30
18:	0	50	8	18:	0	27.	45	11.	11.	30
19:	0	47	30	19:	0	24.	30	11.	30,	0
20:	0	45	0	20:	0	22:	15	11,	22.	30
21:	0	42	15	21:	0	19.	30	11.	22,	30
22:	0	38	0	22:	0	15:	30	11.	15.	0
23:	0	34	40	23:	0	12.	0	11.	20.	0
24:	0	29	35	24:	0	7:	0	11.	17.	0
25:	0	22	20	25:	0	0: *From N to W*	8	11.	14.	0

The way of finding the variation after this manner is eaſy to be conceived. A time being choſen when the Heavens were like to be unmasked for the whole day, the altitudes of the Sunne were taken by him to each degree of a Quadrant both forenoone & Afternoone, from 17 to 25 gr. making nine ſeverall obſervations. And at every Altitude turning his Needle to the Sunn, obſerved the degree and parts cut thereby. Then comparing the *Magneticall Azimuthes* made in the Forenoone, with thoſe in the Afternoone anſwerable to the ſame Solar altitudes, the halfe of the difference is the variation. Thus at the altitude of 17 gr. in the Forenoone

Forenoone, the *Needle* cutting 52 gr. 35 min. and at the ſame altitude in the Afternoone 30 gr. 0 min: the difference is 22 gr. 35 min: the halfe whereof is 11 gr. 17 min: 30 Sec. the variation inquired.

Before we proceed to other Obſervations it will be requiſite we take a review of theſe, and after correction of ſome of the apparent Altitudes, call the Solar Azimuthes to the Iudicature of a Triangle.

It is not unknowne that about this time of *Mr. Burrowes* his obſervations the accurate and corrected tables of the Sunnes motion were not publiſhed to the world, Neither the Angles of the Obliquity and Paralaxes of the Sunne ſo truely determined. And as for the refraction (which inſinuates it ſelfe in every Altitude not exceeding 45 degrees) being then in its infancy and a ſtranger to the world it was not called into the account, no not by the Ancients themſelues, nor limited before that great Aſtronomer and honorable *Dane Tycho Brahe* opened the ſame way. If therefore we ſhall examine theſe Altitudes acording to the late corrected grounds, we ſhall ſomewhat alter the variations of Mr. *Burrowes*, but ſo as that we ſhall not much differ from him, or ſuſpect any great error in his worke.

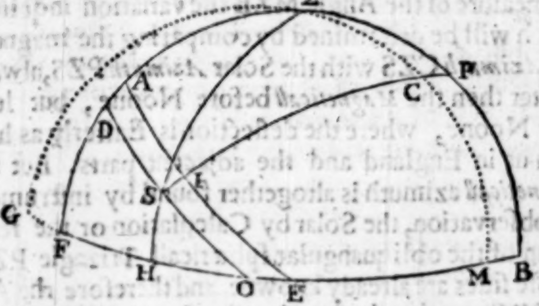
Theſe obſervations then of his, were made the 16 of *October* Anno 1580. And by *Aſtronomicall Calculation* ſhould begin about 9 ½ in the Morning, and end about 2 ½ in the Afternoone. Let us now make choice of the *Magneticall Azimuthes* anſwerable to the Altitudes of 20 gr. being the fourth obſervation. The true place of the Sunne about this time correſpondent to this Altitude according to the late *Rudolphine* Tables, (with conſideration to the difference of *Meridians* and Equation of Time) is thus found after the Centeſimall way with the connexion of our *Britiſh Logarithmes*, but with ſome alteration of the Anomalies

	Motion of the Apog. ☉		*Middle motion of the Sun*	
	Sig.	*Gr.*	*Sig.*	*Gr.*
Epoch of Chriſt	2:	83455571829	9:	88667238532
yeares 1579	0:	270303979753	0:	111927414346
*Month: Biſſ:*9.	0:	00 128419571	9:	00672704358
Dayes 14.	0:	000007030268	0:	137990576119
*Hor.*21.*Min.*9	0:	00000413028	0:	08686013944
Sum of the mot.	3:	53895414449	7:	47943947299
Motion of the Apogæum ſubſtracted			3:	53895414449
The middle *Anomaly*.			3:	2940485328 50
Our Tabular middle *Anomaly*			3:	29 00000
The difference of *Anomalies*			0:	040485
The logarithme whereof is			0.	6072976
The diff. of the Coæquated *Anom.*			1.	01729167
The logarithme whereof is			0:	0074454
The ſumme of the logarithmes			0:	6147430
To which there anſwers				04118538
which added to the tab: *Coaq: Anom*			3.	271763527
Gives the inquired *coaq: Anomaly*			3.	275882065
To this the *Apog*: added			3.	53895414
Gives the Sunnes place in ♏				29777479
The declination whereof is				12548280
Whereunto adding a Quadrant				90000000
The ſum is the ☉ diſt. from the Pole				102548280

And becauſe we haue made choice of the apparent Altitude of 20 gr. the Parallax (*Kepler* admitting little or none,) according to *Tycho Brahe* will be

ſound	*Gr.* 0 047778
And the refraction	0 075000
The difference is	0 027222
Which ſubſtracted from the apparẽt Alt.	20 000000
Giues the true Altitude of the ☉	19 972778
The complement whereof is the diſtance of the ☉ from the *Zenith*	70 027222

That the inſuing work may be the better cõceived, let FZB (in the annexed ſcheme) be the *Meridian* of *Limehouſe*; Z the zenith or *Pole* of the *Horizon* FOB. The elevation of the *Pole* PB. ZP the complement thereof. AE the Equator. The Southerne Parallell of the Sunne DSO. ZSH a Quadrant of a verticall Circle interſecting the Sunnes parallell, and paſſing through his Center in the point S. HS the Sunnes Altitude aboue the Horizon; and ZS the complement or his diſtance from the zenith. SI the declination. SP the diſtance of the Sunne from the *Pole* of the world. Alſo let the obſcure periphery MZG be the *Magneticall Meridian* paſſing through the zenith Z, and deflecting or



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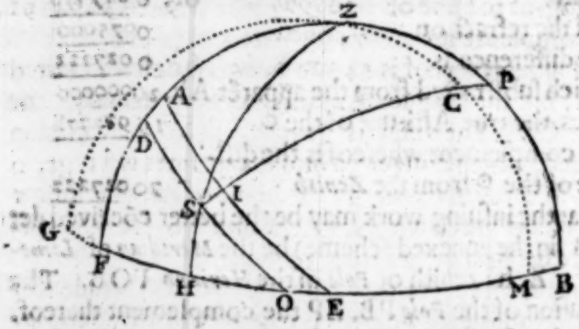


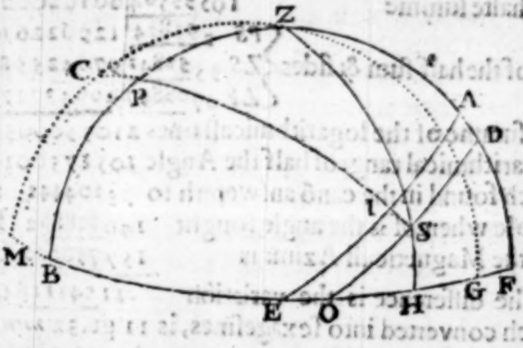
varying from the Terreſtriall Meridian the Arc MB, the meaſure of the Angle MZB the variation inquired, which will be determined by comparing the magneticall *Azimuth* CZS with the Solar *Azimuth* PZS, always greater then the *Magneticall* before Noone, but leſſe after Noone, where the deflection is Eaſterly as here with us in England and the adjacent parts. But the *Magneticall* azimuth is altogether found by inſtrumentall obſervation, the Solar by Calculation or the reſolution of the obliquangular ſphæricall Triangle PZS, whoſe ſides are already knowne, and therefore the Angle PZS may be obtained by the fourth compend of the laſt chapter of the Britiſh *Trigonometry* after this manner.

		Logarithmes
PS. Diſt. of the ☉ frõ the *Pole*	10254789	00269391447
ZS. Compl. of the ☉ altitude	7002722	02061682627
ZP. compl. of the Latitude	5846667	
Sum of the ſides	21104178	
The halfe ſumme	10552089	99838665722
Diff. of the Baſe and ½ ſumm.	297299	87148768587
		189318508383

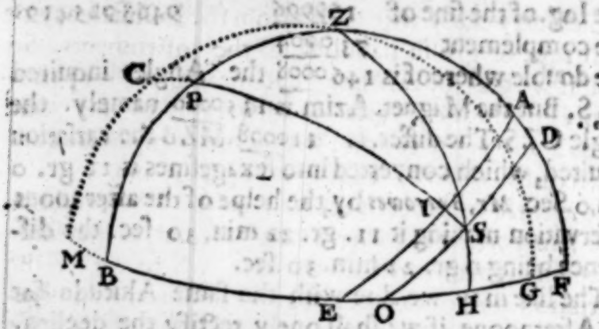
The

The log. of the ſine of 169996 94659254191
The complement 730004
The double whereof is 1460008 the Angle inquired P Z S, But the Magnet. Azim. is 1350000 namely the Angle CZS. The differ. is 110008 MZ is the variation inquired, which converted into ſexageſmes is 11 gr. 0 min, 0 Sec. *Mr, Burrowes* by the helpe of the afternoons obſervation making it 11. gr. 22 min. 30 ſec. the difference being 0 gr. 22 min. 30 ſec.

The like may we doe with the ſame Altitude for the Afternoone, if we ſhall onely rectify the declination anſwerable to the Sunnes motion for the intervall of time. The Sunnes true place was in 3179445 of ♏; the declination correſpondent was 1261740. Then in the adiacent diagram, being the ſame with the former, ſave onely that the magneticall Azimuth CZS is (as it ought to be) greater then the Solar PZS, we have the ſame termes given, and therefore by reſolving the



Triangle PZS, the angle inquired PZS may be found either by the former or the third variety belonging to the 11 Probleme of the ſame booke, and agreeing as well



well with the Calculation of a Plane Triangle as of a Sphæricall, after this manner.

	Gr.	Logarithmes
PS. diſt. of the ☉ from the *Pole*	10261740	
ZS. compl. of the ☉ Altitude	7002722	
ZP. compl. of the Latitude	3846667	
The ſum of the ſides	21111129	
The halfe ſumme	10555564	00162066869
Dif. of the half ſum & ſides *PS*	293824	12902261021
Dif. of the half ſum & ſides Z*S*	3552842	97642558829
Dif. of the half ſum & ſides Z*P*	6708897	99643117219

The ſumme of the logarithmicall ſines 210350003938
Logarithmical tang: of half the Angle 105175001969
which found in the canõ anſwereth to 73104441 the
double whereof is the angle ſought 146208882 PZS
But the Magneticall Azim: is 157750000 CZS

The difference is the variatión 11541118 *CZP*. which converted into ſexageſmes, is 11 gr. 32 *min*. 28: ſec. And if with this we compare the morning variation, (which ſhould have been the ſame with the afternoones) the difference will be 32 *min*: 28 ſec:

which

which may eaſily ariſe either from the Inſufficiency or Fabrique or groſſe handling of the Inſtruments. So that if we take the Arithmeticall meane, we may probably conclude the variation anſwerable to his time to be about 11 gr. 16 min: with which very neere concurreth *Dr. Gilbert*, finding it 11 gr. 20 min.

From theſe we proceed to *Mr. Gunters* Obſervations, the Table whereof we have here inſerted, as we finde them in his mathematicall workes, where we ſee the variation not to exceede 6 gr. 13 min. His inſtruments were one Quadrant of three foote Radius for the Sunnes Altitudes: His Needles were two, the one of ſix, the other of 10 Inches in length. The Sunnes Azimuthes were found by calculation, and the Azimuthes *Magneticall*, taken off a Horizontall Plane by a line of Chordes, whoſe Semidiameter was twelue Inches.

Mr. *Gunters* Obſervations made at *Limehouſe* *Iun:* 13 *Anno* 1622 after Noone.

Alt: ☉		*Azim: Mag*		*Azim:* ☉		*Variation.*	
Gr.	*Min.*	Gr.	Min:	Gr.	*Min.*	Gr.	*Min.*
19	0	82	2	75	52	6	10
18	5	80	50	74	44	6	6
17	34	80	0	74	6	5	54
17	0	79	15	73	20	5	55
16	18	78	12	72	32	5	40
16	0	77	50	72	10	5	40
10	10	71	2	64	49	6	13
9	52	70	12	64	25	5	47

Thus haue we prooved that for the Interſtice of 42

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yeares, there hath beene an evident diminution of five degrees variation. I deny not the Artifice to be very nice and ſubtle, and that an error may vnawares eaſily inſinuate it ſelfe, which together with this great diſcrepance, moved ſome of us to be overhaſty in caſting an aſperſion of error on *Mr. Burrows* obſervations, (though ſince upon noe juſt grounds) till an acquaintance of ours, lately applying *Mr. Gunters* owne Needle to the ſide of the Cubicall Stone of his *Ma*jeſties Diall in White Hall garden, could not finde the variation ſo great as 6 gr. 15 min: formerly found; whereupon reſolving with ſome friends to make an experiment hereof, we went to *Diepford* the laſt yeare 1633 the day of the Sunnes entrance into the ſummer Solſtice, to the very ſame place where *Mr. Gunter* heretofore had made obſervation, and found it much leſſe then fiue degrees; And afterwards calling into Queſtion the Inſufficiency of our Inſtruments, that all ſcruple might be quite taken away, we had recourſe this preſent yeare 1634 Iun. 12. ſtilo vet: to the ſame Garden of our learned and ingenuous friend *Mr. Iohn Welles*, with a Quadrant of ſix foote Radius for ſolar Altitudes, continually rectified with great care, and a Horizontall Quadrant of two foote Radius, for the determining of the *Magneticall* Azimuthes, exactly ſet to the *Magneticall* meridian, and in paralelliſme to the Horizon; (otherwiſe great error might enſue) with two Needles of twelue Inches in length, well touch't with good *Magnetts*; And for the better ſatisfaction, tooke with us alſo the very ſame Needle wherewith *Mr. Gunter* made the foreſaid obſervations, in length ten Inches, all three muſt, accurately reſpecting the ſame *Magneticall Meridian* as we then proved. And leaſt there might ariſe ſome diverſity in the variation through the touches of ſeverall Stones, I cauſed the one Needle firſt touch't by a very good *Magnet*, to be retouch't by another as good if no better, and the ſame wherwith moſt of our zea compaſſes are touch't, and yet found no difference betweene them. And ſo Iune the 14. 1634 we made theſe following obſervations, where we found the variation not to exceed 4 gr. 10 min. as appeareth by the Table annexed.

And becauſe in the Reſolutions of theſe obliquangular ſphæricall Triangles for the Solar Azimuthes we have neceſſary uſe of the Latitude of the Place, the ſame we determine by the Sunnes meridian Altitude to be 51 gr. 30 min. after this manner.

	Gr.	′	″
The apparent Altitude of the Sunne	62.	0.	0
The Parallax of the Sunne added	0.	1.	22
Therefore the Sunnes true altitude	62.	1.	22
Sunnes declination according to *Tycho*	23.	31.	22
Hence the Altitude of the Equinoctiall	38.	30.	0
The compl. wherof is the hight of the *Pole*	51.	30.	0

Obſervations made at Diepford An. 1634 Iunij 12 before Noone

Alt: ⊙ vera		*Azim: Mag*		*Azim. ⊙*		*variatio*	
Gr.	Min.	Gr.	M.	Gr.	M.	Gr.	M.
44,	45.	106,	0	110	6	4.	6
46,	30,	109,	0	113	10	4	10
48,	31,	113,	20	117	1	4	1
50,	54,	118	0	122,	3	4.	2
54,	24,	127	0	130	55	3	55

Teſtibus at ſocius

is D. { *Welles.* *Harriſon.* *Marr.* *Butler.* *Hooton.* *Ho.kwell.*

Alter

After Noone the ſame day.

Alt. ⊙ *vera*		Azi. *Mag*		*Azim.* ⊙		*Variation*	
Gr.	*Min.*	*Gr:*	*M.*	G,	*Mn.*	*Gr,*	*Min*
44	37	114:	0	109.	53.	4:	7
40	48	108:	0	103,	50	4:	10
38	46	105.	0	100,	48	4.	12
36	43	102,	0	97.	56	4.	4
34	32	99,	0	95,	0	4:	0
32	10	96:	0	91.	55	4.	5

These Concordant Obſervations can not produce a variation greater then 4 gr. 12 min. nor leſſe then 3 gr. 55 min. the Arithmeticall meane limiting it to 4 gr. and about 4 minutes.

And for a further confirmation herof (though moved upon no juſt reaſon to ſuſpect theſe obſervations, being every way as cautelous in them as poſſible we could) as ſoone as the intermiſſion from my publique Exerciſe would permit, I cauſed the ſame inſtruments to be tranſported to *Paules Cray* in *Kent*, diſtant from *London* SE and by S about 12 miles, where the fourth of *July* following (*Fide Aſtronomica*) I made the ſubſequent animadverſions, hardly amounting to 4 degrees.

The Latitude of the Place I finde by the ſame large Quadrant to be 51 gr. 25 min. which thus I prove.

	°	'	''
July 21 the ⊙ apparent meridian altit. was	56:	53:	0
The Sunnes parallex to be added	0,	1.	36
The ſum is the Sunnes true Altitude	56,	54,	36
The declination of the Sunne ſubtracted	18,	19,	36
The Relique is the altitude of the equinoc.	38.	35.	0
The compl: wherof is the hight of the *Pole*	51.	25,	0

Obſervations made at Pauls Cray in Kent July: 4: 1634: After Noone.

vera alt. ⊙		*Azim:mag*		*Azim:* ⊙		*variatio*	
Gr,	*Min:*	*Gr,*	*Min:*	Gr.	Min:	Gr:	Min
40:	55.	111	30	107	30	4	0
40:	1	110	0	106	5	3	55
39:	41.	109	30	105	34	3	56
38:	42.	108	0	104	5	3	55
35:	32.	103	30	99	32	3	58
34.	49.	102	30	98	32	3	58
33,	41,	101	0	97	0	4	0
32.	57:	100	0	96	2	3	58
32:	9,	99	0	94	58	4	2
31,	25,	98	0	94	0	4	0
30:	39:	97	0	93	1	3	59
29:	29:	95	30	91	31	3	59
27,	51:	93	30	89	28	4	2

It were needleſſe having ſo many ſufficient teſtimonyes, to produce any more; one onely obſervation made with circumſpection being as good as one hundreth. So that its plaine, the obſervations made in this place do all make the variation to fall neere upon 4 degrees.

Hence therefore we may conclude that for the ſpace of 54 yeares (the difference of time betweene *Mr. Burrowes* and theſe laſt obſervations of ours) there hath beene a ſenſible diminution of 7 degrees and better.

If any affected with magneticall Philoſophy ſhall yet deſire to ſee an experiment made for their owne particular ſatisfaction, where I may prevaile, I would adviſe them to pitch a faire ſtone parallell to the Horicon there to reſt immoveable, and having a Needle of a convenient length ſtrongly touch't by a vigorous Magnet to draw a Magneticall Meridian thereby, and yearely to examine by the application of the ſame (well preſerved from the ayre and ruſt, its greateſt enemies) whether time will produce the like alteration.

I will not here enter into a diſpute concerning the cauſe of this ſenſible diminution, whether it may be imputed to the *Magnet*, or the Earth, or both. It is not unknowne to the world, how the Greateſt *Maſters* of Aſtronomie, which this age hath afforded, for the more eaſy ſalving the apparent anomalar motions of the fixed and erratique cæleſtiall lights, and avoyding that ſupervacaneous furniture of the Ancients, do with all alacrity embrace that admirable *Copernicean Hypotheſis* of the diurnal, Annual, & Secular motions of the earth, in ſo much as conferring with that Great Aſtronomer *D. Phil. Lanſberg.* in *Zealand* about Aſtronomicall matters, did moſt ſeriouſly affirme unto me, he ſhould never be diſſwaded from that Truth. This which he was pleaſed to ſtile a truth, I ſhould readily receive as an *Hypotheſis*, and ſo be eaſily led on to the conſideration of the imbecillity of *Mans* apprehenſion, as not able rightly to conceive of this admirable opifice of God or frame of the world, without falling foule on ſo great an abſurdity. Yet ſure I am, it is a probable inducement to ſhake a wavering underſtanding. And which adds ſomewhat more, I underſtand by *Galilæus* a *Florentine*, and a moſt acute and learned *Mathematician*, that an *Italian* Gentleman of the Family of the *Marſilij*, hath lately found the mutation of the Terreſtriall *Meridians*, and penned a treatiſe thereof not yet publiſhed, which the ſaid *Galilæus* hath ſeene and read *con ſtupore*, not without amazement. His words are theſe.

Surge

Surge di preſente una quinta novita, dalle quale ſi poſſa arguir mobilita nel globo terreſtre, mediante quello, che ſottiliſſimamente va ſcoprendo l' illuſtriſſimo S. Cæſare della nobiliſſima famiglia de i Marſilii di Bologna, pur' Academico Linceo; il quale in una dottiſſima ſcrittura va eſponendo, come ha oſſervato una continua mutazione, benche tardiſſima, nella linea Meridiana; della quale ſcrittura, da me ultimamente con ſtupore veduta, ſpero che douera fare coppia a tutti gli ſtudioſi delle maraviglie della natura.

Which in Engliſh runnes thus.

Now there ariſeth a fift noveltie, from which we may argue the mobility of the terreſtriall Globe, by the meanes of that which moſt ſubtilie the moſt illuſtruous Gentleman *Sig*: *Cæſar* of the moſt noble familie of the *Marſilij* of Bologna, a Lyncean *Academicke* alſo, hath diſcovered, who in a moſt learned tract plainely ſheweth how he hath obſerved a continuall mutation, although very ſlow, in the Meridian line; which diſcourſe, which with wonder I lately ſaw, I hope he will impart to all thoſe who are Studious of the wonders of nature.

Surely if it be ſo, the due conſideration of the premiſſes doth (as I conceive) lay open a faire way for the ſalving of that Irregular Motion imputed to the Axis of the Earth. I meane the alterable Obliquity of the Ecliptique, which to deny (as ſome yet doe, not without great violence offred to the Ancients) I ſhall hardly (without very ſtrong argument) be perſwaded. I pretermit likewiſe a ſuppoſition which might be made of the correſpondent motion of the *Pole* of the Magnet with thoſe of ſome of the Planets, and divers other conceits, which muſt be all left to future times to diſcover, this Invention being but newly preſented to the world in its infancy.

Greſham College 5 *Cal.* *Aug.* 1634.

Errata *Typographica.*

PAg. 7 lin. 1. for *Gilberts* read *Gilbert*. Pag. 7 lin, 16 for *Dedford* read *Diepford*. p. 9 lin 19 for the ſame way, read the way. p. 9 lin. 27 for $9\frac{1}{3}$ read $9\frac{1}{2}$. p, 13, lin, 12, for internall reade intervall: pag, 16 lin laſt for muſt reade moſt:

FINIS.